with, better systems imposed upon their tenants by landlords. To-day, if English farming practice is in many respects still ahead of its competitors, it has become, comparatively speaking, not so alive to the applications of science. Farmers themselves are not quite what they were; the great industrial development of the last sixty years has been drawing away the brains from the more slowly moving pursuit of agriculture, and, speaking broadly, the present race of farmers are not educated up to their needs or their opportunities.

Here again the landowners have not been, but can be, leaders; they can become intelligence centres, they can stimulate the education of their tenants and of their tenants' sons, they can even insist on education in selecting their tenants. It is the lack of appreciation of science among landowners that has made it a plant of slow growth among their tenants.

The address is really a powerfully worded appeal from Lord Bledisloe to the landowning class to treat landowning as a vocation and to educate themselves for it. It is a far-sighted call for service, and coming from one who has so notably put into practice what he preaches, carries with it an authority which no ordinary admonition to progress can possess.

Bergson and Einstein.

Durée et Simultanéité: À propos de la théorie d'Einstein. Par Henri Bergson. Pp. viii + 245. (Paris: Felix Alcan, 1922.) 8 francs net.

EINSTEIN in his theory of relativity may be said to have thrown down a challenge in the scientific world of the same kind as that which Bergson in his theory of duration has thrown down in the philosophic world. Both theories are primarily concerned with a certain fundamental character in the experience of time. Both recognise a difference of nature, that is, a qualitative difference, between the time which enters into our equations of measurement and the time which is lived. At one point, however, Bergson seems to come into direct conflict with the Minkowski-Einstein scheme of a space-time continuum. This is in his conception of creative evolution. Creation means that the reality of the physical universe is of the nature of life or consciousness, a conception which implies the continued existence of the past in the present, and a universal moving forward into an open future. How is this consistent with the view that there is not one single universal time but as many different times as there are systems, and that there is no absolute simultaneity between events which take place at any two points if they are separate from one another in space?

Bergson has evidently been of opinion that for his own sake he must clear up his position on this crucial point. To do so has been no slight undertaking, for he has not been content to accept the principle of relativity from the physicists or to assume that its mathematics is correct. He has, therefore, deferred the resumption of his own philosophical work, interrupted by the war, and has set himself to study at first hand the mathematical equations of Lorentz and Einstein. It may interest readers of NATURE to know that Bergson specialised in mathematics in his student days to the extent of hesitating between it and philosophy when he had to choose a profession. The argument in his new work deals almost exclusively with the restricted theory, for it is that which affects directly the question of the reality of time. The relevance of the generalised theory is only touched upon. It is the subject of a "Final Remark," in which the nature of its importance for philosophy is indicated, but general relativity does not seem to Bergson to challenge, as the restricted relativity does, his theory that time as a universal flux or change is an intuited reality, while successive states are a spatialised time due to the intellectual mode of apprehending it.

Descartes in the Principles (ii. 29) declares that in movement there is complete reciprocity; either of two objects changing their relative position may be considered as having moved or as having remained at rest. To this Sir Henry More replied (March 5, 1649): "When I am sitting still, and someone moving away a mile from me is red with fatigue, it is he who moves and I who am still." Nothing science can affirm concerning the relativity of perceived movement, measured by foot-rules and clocks, can disturb the inward feeling we have that we ourselves can effect movements and that the efforts we put forth in doing so are under our control. Here we have, then, in the most striking manner, the contrast between the intuitive mode and the intellectual mode of apprehending reality. Is there anything in the principle of relativity which conflicts with the conception of reality as fundamentally a duration which is intuited or lived? *Prima facie*, yes. The denial of absolute simultaneity seems completely inconsistent with it. This comes out most clearly in Einstein's paradox. "Suppose a traveller to be enclosed in a cannon-ball and projected from the earth with a velocity amounting to a twenty-thousandth of the velocity of light; suppose him to meet a star and be returned to earth; he will find when he leaves the cannon-ball that if he has been absent two years, the world in his absence has aged two hundred years." Any one who applies the mathematics of relativity and makes the simple calculation for the two systems, earth and cannon-ball, will find that the conclusion follows with the same logical necessity as in Zeno's paradox that Achilles cannot overtake the tortoise.

There is, however, a limitation even for the relativist which, although it falls short of establishing an absolute, is important to keep in mind. There is no system of reference which a traveller can choose, by entering which he might depart and return to find the world younger, so that his journey would have been backward in time. The reason is not the inconceivability of such a system, but the fact that it would bring us into conflict with the law of causality. The reversibility of causality which would require the effect to come into existence before the cause, is unthinkable. Such then is the paradox. Relativity requires that as we pass into a new system of reference the relative movement of the new system shall be compensated by changes in the spatio-temporal axes of co-ordination in order to keep constant the velocity of light. This means in the case supposed that two years of the one system is the equivalent of two hundred of the other.

Bergson's solution of Einstein's paradox follows the same line as his solution of the paradoxes of Zeno, but the special application of his principle has a particular interest. In the case of Zeno the essential point was the insistence on the continuity, in the meaning of absolute indivisibility, of true duration, the duration which is lived and intuited, as distinct from the infinitely divisible continuity, mathematically defined, of the schematised trajectory of the movement. The mathematical time which we measure is really space. In the case of Einstein's paradox Bergson argues that the two systems, which are discordant as to their simultaneity when taken as integral systems, must be considered as continuously related, and this is possible only so long as we do not abstract from the observer who is attached to each. If, he says, we consider the two observers in their different systems to be continuously in communication it is clear that each, while regarding the other as a physicist co-ordinating a system, will regard that co-ordinated system from the standpoint of his own, and therefore, however different the system may be, in so far as the two observers are physicists and in so far as they are related observers, the duration intuited is one and the same for both. But here we shall ask, if the explanation is so simple, how does the paradox arise? Quite naturally, Bergson replies, and this is the striking part of his argument, because what the philosopher can do the physicist cannot. The philosopher's concern is with reality perceived or perceptible; he, therefore, can never lose sight of the interchangeability of the two systems. He keeps them together by a kind of continual coming and going between them. The physicist, on the other hand, whose only business is to co-ordinate the system as a whole, must choose one and stand by his choice. He cannot relate all the events of the universe to two systems of different axes of co-ordination at one and the same time. He must therefore regard the whole system as concordant or discordant with the whole of the other system, each taken as one and integral. For the physicist is not concerned with time intuited but only with time as a measurable dimension.

We may see, then, how Einstein is able to affirm that there are multiple times. We can place an imaginary physicist at every point of space and his time-system will necessarily be different from every other time-system; and our own time-system, so far as we are physicists, has no privilege over the imaginary time-systems. But, Bergson replies, into whichever of these imaginary time-systems we project ourselves, it becomes thereby time lived or intuited, and as we can conceive ourselves to pass into any of them, there is a real duration to which all the imaginary time-systems belong. Thus is restored to us the unique time, one and universal.

Such is Bergson's solution. Does it dispose of the problem? The argument is certainly calculated to reassure those who have been disturbed by the principle of relativity, and to comfort those who are made unhappy, rather than stimulated to activity, by paradox. Yet there are many indications in his book that Bergson himself does not feel he has said or is now saying the last word. In the final remark, to which we have already referred, he regards the generalised theory as an extension of the argument of the restricted theory with the difference that the emphasis is on space rather than on time. He suggests that the treatment of space on the same lines as those on which he has dealt with time would show that the multiple geometries are imaginary physicists' geometries abstracted from their relation to and transformability into the one and universal space-system which is the intuition of the living individual.

To a certain extent he is undoubtedly right, for we may say truly that the restricted relativity is a case in point of the generalised relativity. But there is a problem which Bergson has left untouched while giving indications that he is aware of it. This is the relativity of magnitudes. Even Einstein has not, so far, dealt with it specifically. Weyl, in his endeavour to make the generalised theory include the whole realm of electro-magnetic phenomena, has foreshadowed a relativity even more fundamental and more universal than Einstein's, although so far he has found no means, such as Einstein found, of submitting the principle to experimental tests. In philosophy it is of the deepest significance. Not only is there no absolute criterion of magnitude, but systems of reference are not even relatively in relations of magnitude to one another. It is only for the observer in a system of reference that there is a relation of magnitude within the system and that the system itself has relations of magnitude to other systems. Into whatever system an observer passes he carries into it his own constant norm of magnitude and he does not have to submit to the dimensions which the new system imposes on him. It is this aspect of the principle of relativity which has seemed to the present writer to require a philosophical principle like that of the Leibnizian monad to give it full expression. It is not enough to return to the mathematical principle of Descartes's mechanism. Mathematics and physics alike rest ultimately on the experience of active subjects, and this is why experimental tests are relevant. The monadic conception derives new meaning from the theory of reality as psychical duration, the concept which Bergson has made a new possession of human thought.

H. WILDON CARR.

The Molecular Scattering of Light.

Molecular Diffraction of Light. By Prof. C. V. Raman. Pp. x+103. (Calcutta: University of Calcutta, 1922.)

READERS of NATURE are already familiar with the important work which Prof. C. V. Raman has been carrying out in connexion with the scattering of light by small particles, for many of his results have been announced in these columns. In a small volume published by the University of Calcutta he has reviewed the present position of the subject of molecular diffraction of light, and has discussed the theory in a comprehensive survey which includes the case of gases, vapours, liquids, crystals, and amorphous solids.

Lord Rayleigh was the first to indicate the principles on which the problem may be handled, and he obtained a relation between the scattering power of the molecules of a gas, their number per unit volume, and the refractivity of the medium. As the energy scattered must be derived from the primary beam, the intensity of the latter must suffer an attenuation as it passes through the medium, and an expression can be derived for the attenuation coefficient. Prof. Raman discusses some criticisms of the theory and concludes that the principle of random phase which is assumed in the argument is justified, provided there exists the random distribution of the molecules which is required by Boyle's law. The ultimate justification of the principle rests on the complete non-uniformity in the spatial distribution of the molecules in so far as very small volume elements are concerned.

The first successful attempt to observe the scattering of light by dust-free air in the laboratory was made by Cabannes in 1915. Experimental work of great interest has been carried out by Prof. R. J. Strutt (the present Lord Rayleigh), who obtained the remarkable result that, in many gases, the scattered light is only partially polarised. This may be explained as due to the lack of symmetry of the molecules, and may furnish valuable information with regard to molecular configuration.

To the late Lord Rayleigh we owe the brilliant suggestion that the scattering of light by the molecules of air accounted in large measure both for the blue light of the sky and the observed degree of transparency of the atmosphere. Recent observations, principally at the Observatory on Mount Wilson, have confirmed the theory and have furnished a value for Avogadro's constant which is practically identical with that deduced from Millikan's measurements of the electronic charge. Prof. Raman has made observations on the polarisation of skylight on Mount Dodabetta (8750 feet above sea level) in the Nilgiris. As is well known, dust and haze are largely confined to the lower levels of the atmosphere. The influence of secondary scattering may be reduced very considerably by using a deep red filter, and allowance can be made for the effect of earthshine. The weaker component of polarisation was found to have 13 per cent. of the intensity of the stronger component. Only 4 per cent., however, was ascribable to molecular anisotropy, a result in good agreement with the latest laboratory measurements.

The principle of random phase on which Rayleigh's theory depends is not applicable in the case of highly condensed media such as dense vapours, liquids, and solids. In liquids, we may apply the theory developed by Einstein and Smoluchowski, in which scattering is considered not as due to individual particles but to small local variations of density arising from the heat movements of the molecules. A formula is obtained showing how the scattering power of a fluid is related to its refractivity. It is worthy of notice that the scattering power is proportional to the absolute temperature and to the compressibility of the liquid. When corrected for the effect of molecular anisotropy, the formula gives results in fair agreement with observations in non-fluorescent liquids, and it reduces automatically to the Rayleigh formula in the case of gaseous media. But, surprisingly enough, the law seems to break down in the case of gases under high pressure. Prof. Raman makes the interesting suggestion that this failure may mean that the continuous wave theory of light does not strictly represent the facts, and that we may perhaps find here experimental support for Einstein's conception that light itself consists of quantum units.

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